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Technologies and Innovations for Production System in Agriculture: National Policy Provisions and Implementation in Nepal

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Abstract

Nepal's Agriculture has rapidly embraced the concept of development and assessment since the 1960s. However, the intricacies of the sector present an ongoing challenge in identifying the necessary policy actions to foster the evolution of agricultural innovation and technologies. This study aims to review policy provisions concerning agrarian technologies and innovations that stimulate the production system. Additionally, it identifies issues and gaps, formulating potential policy solutions. The research followed a comprehensive three-step process: firstly, listing and reviewing 54 agricultural policies, and 32 acts of Nepal using a set of thirteen indicators. After that, an assessment of implementation status was done. Then consultation and validation of findings were conducted with the experts in the workshops. The findings contribute to a better understanding of policy implementation and the promotion of sustainable agricultural practices. The study found that while many policies aimed to improve agricultural production and productivity, they lacked actual measures to support increased production, such as assisting with essential inputs like labour, capital, and complementary materials. Additionally, it revealed that approximately 9% of agricultural acts and 54% of policies included provisions for production and management system technologies and innovations. However, no policy provisions for developing production technologies were found for "source seed production" and "to conserve and utilize local resources". The study identifies that the current resource allocations for innovative production systems and management technologies are inadequate, particularly in areas like climate change, food safety, nutrition, conservation, biotechnology, and mechanization.

Keywords: Crop management, Indicators, Innovation, Resource Allocation

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कृषिमा उत्पादन प्रणालीको लागि प्रविधि तथा नवप्रवर्तनः नेपालका राष्ट्रिय नीतिका प्रावधानहरू र कार्यान्वयनको अवस्था

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सार

नेपालको कृषि क्षेत्रले सन् १९६० को दशकदेखि नै विकास र मूल्याङ्कनको अवधारणालाई द्रुत गतिमा अङ्गीकार गरेको छ। परन्तु, यस क्षेत्रका जटिलताहरूले कृषि क्षेत्रमा नवीनता र प्रविधिहरूको विकासलाई बढावा दिने आवश्यक नीतिगत कार्यहरूलाई पहिचान गर्न निरन्तर रूपमा चुनौती प्रस्तुत गरेका छन्। यस अध्ययनको उद्देश्य भनेको कृषि प्रविधि र नवप्रवर्तनसम्बन्धी नीतिगत प्रावधानहरूको समीक्षा गर्नु हो । साथै, यसले नीतिगत समाधान पत्ता लगाउनका निम्ति नीति खाडल र अन्य समस्याहरूको पहिचान पनि गरेको छ। यस अनुसन्धान तीन बृहत् चरणमा गरिएको थियो । पहिलो चरणमा, १३ विभिन्न सूचकहरूको प्रयोग गरी ५४ वटा कृषिसम्बन्धी नीति र ३२ कृषिसम्बन्धी ऐनको समीक्षा गरिएको थियो भने त्यसपछि नीतिहरूको कार्यान्वयनको अवस्थाको मूल्याङ्कन गरिएको थियो । यसबाट प्राप्त नतिजाहरूलाई प्रमाणीकरण गर्नका लागि विज्ञहरूसँगको कार्यशाला आयोजना गरिएको थियो । यस अध्ययनले नीति कार्यान्वयनलाई बुझ्न मद्दत गर्नुका साथै, दिगो कृषि अभ्यासलाई प्रवर्धन गर्नेछ । अध्ययनले के पत्ता लगायो भने धेरै नीतिहरूले कृषि उत्पादन र उत्पादकत्व सुधार गर्ने लक्ष्य राखेका थिए, तर ती नीतिहरूमा उत्पादन वृद्धि गर्न अत्यावश्यक हुने श्रम, पुँजी र पूरक सामग्री जस्ता निवेशहरूमा सहयोग गर्ने प्रावधानहरू थिएनन्। यस अध्ययनले ९ प्रतिशत कृषि ऐनहरूमा र ५४ प्रतिशत कृषि नीतिहरूमा उत्पादन र व्यवस्थापन प्रविधि र नवप्रवर्तनबारे उल्लेख गरिएको भेटेको छ। तर कुनै पनि नीति र ऐनमा स्रोत बिउ उत्पादन र रैथाने स्रोतहरूको संरक्षण र उपयोग सम्बन्धमा उल्लेख गरिएको भेटिएन । समग्रमा, यस अध्ययनले खास गरी जलवायु परिवर्तन, खाद्य सुरक्षा, पोषण, संरक्षण, जैविक प्रविधि र यान्त्रिकीकरण जस्ता क्षेत्रमा नवप्रवर्तनकारी उत्पादन तथा व्यवस्थापन प्रणालीका प्रविधिहरू अपर्याप्त रहेको देखाएको छ।

Keywords: Crop management, Indicators, Innovation, Resource Allocation

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1. Introduction

In Nepal, a wide array of policies, strategies, and acts has come into action to enhance the agricultural sector. The past several years has witnessed flare-up evidence of the formation of agriculture and related policies and acts; as the nation has emphasized agriculture since the 1960s (NPC, 1956). The diversity of these policies is notable, covering a broad spectrum of areas ranging from foreign investment and agribusiness promotion to food security, climate change, irrigation, seed development, mechanization, land use, agro-biodiversity, and livestock breeding, among others. For instance, some policies like the Agricultural Development Strategy, 2015-2035 and the Fifteenth Plan, 2019-2024 are instrumental policies that currently guide Nepal's agricultural sector and provide a framework to guide agricultural development efforts. ADS, is a comprehensive plan to promote sustainable and commercial agriculture in Nepal, aiming to increase productivity and farmers' income. The Fifteenth Plan, outlines the government's priorities, including strategies to enhance agricultural productivity, ensure food security, and address challenges in the agriculture sector. Understanding these wide arrays of policies is vital in comprehending the comprehensive framework for agricultural development in Nepal and identifying opportunities for further improvement and effective implementation. While Nepal's policies cover a broad spectrum of areas related to agriculture, there is a need to assess how effectively they address and implement production management technologies to enhance agricultural productivity which largely depends on the successful integration and adoption of efficient production management technologies.

Therefore, production systems and crop management technologies are pivotal drivers of increased agricultural productivity, profitability, and enhanced crop quality while ensuring efficient utilisation of critical farm resources such as labour, soil, water, energy, and costs. These technologies encompass a wide range of strategies, including crop, soil, pest, and water management approaches, contributing to sustainable agriculture by promoting resource conservation, minimising environmental impacts, and fostering resilience to changing climate. Notable examples of these technologies include precision and protected technologies, conservation tillage, integrated soil fertility management, integrated pest management, water harvesting, and management techniques, as well as mechanization technology for planting, weeding, and harvesting. Although some agricultural policies in Nepal briefly mention these technologies and acknowledge their importance, there is a need for a more robust and inclusive approach to incorporate them effectively into the agricultural development framework.

As agriculture has traditionally been the most significant source of food, improvements in technology and infrastructure have brought the evolvement of contemporary industries; from manufacturing to services, which are now more frequently traded across international borders. Nepal has observed an unusual pattern of structural transformation in recent decades in which agriculture contracts and manufacturing peaks prematurely before declining. Poudel & Wagle, (2019) claim that this is due to the drawback of policy discontinuity and armed conflict after the introduction of liberal economic policy in 1990. In a recent study, Khanal et al. (2020) emphasise that most policies and legislation implemented in Nepal have followed a top-down and supply-driven approach, prioritising the relationship between technological inputs and outputs. This approach lacks active involvement from local communities and stakeholders, neglecting the benefits of a bottom-up strategy that considers the comparative advantage and unique characteristics of different ecological zones, particularly in terms of land management. It is evident that policy factors significantly impact the dynamics of productivity growth, and a more inclusive approach involving local communities and stakeholders could lead to improved outcomes in agricultural sectors.

According to Joshi & Joshi (2021), understanding the governance structure and processes, governing policy formulation and implementation is of utmost importance. However, the available information suggests that existing policies in Nepal often face challenges in meeting their targets and provisions during project design and implementation (Timsina et al., 2023). To enhance production system technologies and innovation, examining the relationship between community-based institutions for agriculture governance become vital, which can provide valuable insights for decision-making. In Nepal, the close association between agriculture and the national economy underscores the significance of integrating research and innovation into policies, as it plays a crucial role in supporting and guiding adaptation efforts within the sector.

Hence, the main objective of this paper was to identify and analyse key agricultural policies about production and management research and innovations in Nepal. Additionally, we evaluate the extent to which these policies align with priority, needs, and targeted goals. Furthermore, we aim to examine the formulation and effectiveness of the implementation of production system-related policy provisions in Nepal's agriculture. Ultimately, we aim to provide recommendations to enhance policy outcomes and promote sustainable agricultural development practices.

2. Methodology

An incremental strategy was used to assess agricultural policies and acts. A list of different national agricultural policies documents (54) was taken from related ministries and acts (32) were collected from the official website of the Nepal Law Commission. The study mainly focused on production and management technologies generated by the Nepal Agricultural Research Council (NARC) because NARC is primarily mandated for conducting agricultural research in Nepal and most of the agricultural technologies are developed by NARC. Likewise, the study covered only the federal-level policies not the provincial or local government. The details of the policy documents reviewed are given in Annex 1 and 2.

Secondly, policy documents were chosen for review and assessment through an interactive conversation with policy experts (policies, strategies, and visions, as well as acts relevant to R&D and Innovations in production system technology and management). The expert consultation was used to identify a total of 13 indicators (which are listed in Annex 3) to define the policy provisions for production system technologies and innovation in agriculture. Further, the information was also collected from the 29th National Summer Crop Workshop, and different provincial review workshops organised by NARC in 2023 with the participation of different stakeholders where production management-related technologies were validated.

Finally, the third step involved evaluating the implementation's performance, considering many factors, including organisational, investment, legal, and human resource considerations.

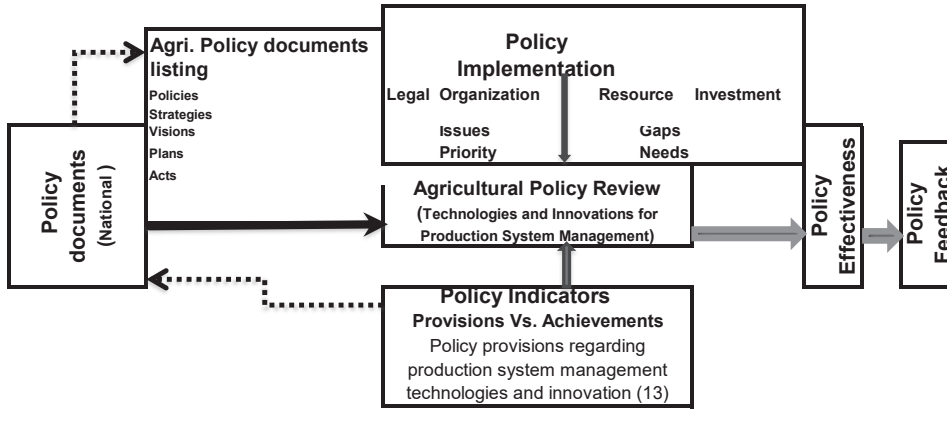

Figure 1: Conceptual framework for policy listing, review, and assessment (adapted from Timsina et al., 2023)

3. Results and Discussion

Based on the indicator (Annex 3) created to review the study, out of the selected, 54 agriculture-related policies (Annex 1), only 54% of them made provisions on production system management, technologies, and innovations. Similarly, among the 32 acts (Annex 2) that were analysed, only 9% of them included provisions related to production management technologies and innovations.

Table 1: Detail analysis of production management system technologies and innovations in different policy documents

Reviewed Documents	Overall provisions of policies on production system technologies		
	Excellent	Good	Fair
Policies: (54)	0	0	30
Acts: (32)	0	0	3

Note: Excellent: clearly explained with indicators; Good: specifically explained; Fair: broadly explained; Out of 54 policies and 32 acts, only 30 policies and 3 acts were reported about production management technologies respectively

Based on the evaluation of the study, it was found that most of the policies and acts were explained in a "fair" manner. They mentioned the topic of production system technologies, but the explanations were broad and lacked specific detail according to the criteria set by the indicator in the study. Among the 54 policies and 32 acts, 24 policies and 29 acts did not include provisions related to production system technologies as specified in the indicators. Table 2 comprehensively overviews of various agricultural indicators, their corresponding frequencies, and quartile classifications.

Table 2: Policy provisions and their priority for indicators related to production and management technologies

Indicators	Frequencies	Quartiles
Productivity and production improvement	18	4
Farm mechanisation and modernisation	11	4
Pesticides and soil health	7	4
Quality improvement technologies (nutrition and food safety)	5	3
Climate resilience, adaptation, risk reduction and mitigation	5	3
Supplementary technology development and management	4	2
Application of biotechnology, and nano-technology for the promotion of agricultural technology and management	4	2

Indicators	Frequencies	Quartiles
Precision agriculture technologies	4	2
Public-private partnership for improvement of agricultural technologies	4	2
Protected agriculture technologies	3	1
Tissue culture	2	1
Production of sources seeds breeds and other planting materials	0	0
Conservation and utilisation of Indigenous/local resources/ materials through both participatory and conventional breeding	0	0

The fourth quartile contains indicators with the highest frequencies, including "productivity and production improvement", "farm mechanisation" and "pesticides and soil health", indicating their highest prevalence in the policy documents, while, indicators such as "production of sources seeds breeds and other planting materials" and "conservation and utilization of indigenous/local resources" have the least policy alignment with zero frequency, implying they were not reported in the documents that were reviewed. The detailed provisions of policies and acts regarding policy indicators are provided in Annex 4 and 5.

3.1 Policy Provisions, Implementation, and Gaps

3.1.1 Production, Productivity, and Quality Improvement Technologies

Out of the 54 policies examined, approximately 22 have acknowledged measures to improve agricultural production and productivity. However, the majority of these policies have only scratched the surface, offering limited details concerning the measures to increase production. These measures include authorising assistance for labour, capital, and material inputs. As, productivity growth in agriculture can be attributed to the adoption of technology and changes such as farm exit and consolidation, which lead to the reallocation of resources towards more productive farms (Thi & Kimura, 2013; Kimura & Sauer, 2015). In the context of Nepal, it was found that different policy documents have shown a recognition of the importance of utilising technologies to enhance agricultural production. For example, the National Coffee Policy (2003) has acknowledged the development of modern and improved technologies for the promotion of coffee production. Similarly, National Science, Technology and Innovation Policy, 2019 briefly mentions technology development to enhance productivity and support economic growth. Among the 32 acts reviewed, only 3 made mention of crop management technologies and innovations. Notably, The Right to Food and Food Sovereignty Act, of 2018 vaguely refers to expanding the sustainable use of and access to improved technology in

food production. Similarly, the NARC Vision, 2011-2030 outlines a comprehensive plan to develop appropriate technologies for various agricultural aspects, such as low-cost solutions, climate resilience, water conservation, and resistance to drought and pests. Additionally, it aims to capitalise on indigenous technology and knowledge originating from farmers, agro-veterinarians, and others involved in agriculture-related economic activities. The vision emphasises the development of technologies for early and full-season pollinated varieties (OPV) of maize to enhance maize productivity. It also aims to create proper moisture conservation technologies applicable to both upland and lowland rain-fed cropping systems. Overall, the NARC Vision, focuses on utilizing diverse technologies to enhance agricultural production effectively.

In Nepal, the Nepal Agricultural Research Council (NARC) plays a pivotal role as the central institution for the development of agricultural technologies. A substantial portion of technology development has been observed to be carried out through NARC, leading to significant progress in implementing various production and management technologies which are grouped into three categories: yield-enhancing technologies, cost and resources-saving technologies, and quality-enhancing technologies. Where yield-enhancing technologies include the successful development of crop varieties tolerant to drought, floods, extreme heat, colds, pests, and diseases, some of the important examples include drought-tolerant rice varieties (e.g. Sukha-1, 2, 3), flood-tolerant rice (e.g. Swarna Sub-1, Shamba Sub-1), disease-resistant wheat, and high-temperature-tolerant maize hybrids. Likewise, the cost and resources-saving technologies comprise zero/minimum tillage, surface seeding, crop residue management, nutrient management, and precision maize transplanters. Similarly, quality-enhancing technologies encompass micronutrients-rich crop varieties (e.g. Zinc rich wheat, lentil), a low-cost solar dryer for drying high-value vegetables, fruits, meat, and fish products, as well as a millet thresher for reducing the drudgery of women and promoting traditional nutrient-dense crops (Gauchan et al., 2022).

Furthermore, NARC has developed other crop and natural resource management (NRM) technologies. These include digital soil mapping (DSM) for efficient nutrient application based on soil attributes, disease and pest management technologies applied in crops such as fall army-worm management in maize, and *Tuta* management in tomato. Additionally, NARC has contributed to the advancement of inter-cropping, multi-cropping, crop rotation, and agro-forestry technologies, tissue culture technologies for disease-free seeds and seedlings, and the application of biotechnology and nuclear technology in agriculture (Timsina, 2023). Similarly, Gairhe & Paudel (2019) reported about 19 major production technologies in the

fisheries sector and 26 major such technologies in the livestock sector was developed by NARC until 2018.

However, farmers' ability to adopt new technologies is often constrained by factors like limited access to information, finance, and labour, especially among smallholders in tropical regions (Barrett et al., 2004). Policies should be developed considering farmers' adoption capability to effectively distribute technologies in Nepal's farming. Project and policy interventions are essential to encourage the adoption of high-return technologies.

3.1.2 Climate Adaptation and Risk Reduction Integration in Agricultural Policies

The policies formulated over the last decade show a growing awareness of climate change in agriculture but only a few have acknowledged tactics for both adaptation and mitigation of climate-resilient agriculture and risk reduction technology. The first Climate Change Policy for Nepal was formulated in 2011. Before these specific climate change policies, sectoral policies hardly ever addressed climate change and resource usage issues. With climate adaptation considered a bigger problem than climate mitigation, most of the climate change policies focus more on climate adaptation rather than mitigation (Baniya et al., 2021). NARC Vision (2011-2030) has emphasised the promotion of climate-friendly agricultural technologies to adapt to climate change and contribute to sustainable agriculture development. Likewise, the Agriculture Development Strategy (2015-2035) has highlighted building resilience for farmers to climate change as well as the adoption of good agricultural practices (GAPs) for food safety and risk in agriculture and nutrition security. It further mentions establishing climate information and weather indexation systems designed to provide information to farmers and build capacity for crop yield forecasting based on weather indexation. The strategy also emphasizes promoting campaigns to farmers on agricultural insurance products which include the Weather Based Crop Insurance Scheme (WBCIS).

Similarly, the Fifteenth Plan (2019-2024) acknowledges the introduction of resilient technology to combat climate change, including the use of an early warning system, for preparation and adoption of the climate adaptation process. In addition, the revised Climate Change Policy, 2019 highlights the development of technologies to protect crops from climate-induced disasters and improve agricultural productivity. It has further mentioned making preparedness and response effective by developing monitoring, forecasting, and early warning systems for various disasters. Similarly, the National Science, Technology and Innovation Policy, 2019 has conceded the inclusion of scientific research and technology development for climate change

adaptation, and disaster risk reduction. As mentioned by Timsina et al. (2023) even though the policy provisions have resulted in minimal or limited development of crop management technologies to combat the negative effects of climate change, the main focus of NARC (Nepal Agricultural Research Council) is primarily on the development of climate resilient varieties.

3.1.3 Precision Farming (PF)

Precision agriculture is a management system based on information and technology that analyses the spatial and temporal variability within the field to maximize production, profitability, and environmental sustainability. The relevance of PF will rely on the co-evolution of technological, economic, and policy-related elements only with the availability of affordable tools to the farmers can they make informed management decisions and reap the potential for significant economic and environmental advantages. In contrast, the current usage of PF is moderate and (for the most part) is practised at larger, highly capitalized farms in developed nations (Griffin et al., 2018; Finger et al., 2019; Shrestha & Khanal, 2020).

In Nepal, there are some precision agriculture technologies used by government institutes and smart farmers. The technologies include; greenhouse monitoring systems, sensor-based temperature and relative humidity management by the use of mobile apps for greenhouse, soil-less farming (hydro and aero-ponics, the use of drones for spraying micro-nutrients and pesticides, vegetable and flower seedling production using hi-tech structures, apps controlled hydroponics systems (Atrya et al., 2020). Poudel et al. (2023) while examining one of the precision agriculture technologies: Laser-assisted Land Levelling (LLL), suggests that, based on the heterogeneous demand seen across different farm size quantiles, different policy instruments and rural development strategies needed for small and large farms. However, policy analyses showed that approximately 7% of the total policies mentioned PF, with the Irrigation Policy (2004) acknowledging updating Geographical and Managerial Information Systems (GMIS) at every level of implementation for the irrigation program. The National Agricultural Policy, 2004 has provision to establish a survey/surveillance system to assess the impact of excessive rains, droughts, diseases, insects, and other natural calamities and mobilize agricultural reliefs. Spatial mapping of soil has already been developed by NARC, likewise, spatial and temporal mapping of disease and pests or the field moisture could be a valuable policy instrument for early diagnosis and management strategies. Land pooling has also been a priority of the National Agricultural Policy, 2004 as well as the Agriculture Development Strategy 2015-2035, implemented through the Prime Minister Modernization Project (PMAMP), which could be

considered as precision farming targeting efficient utilization of resources. Although PF is profitable and cost-effective, it has some issues in implementation in the context of Nepal, which include lack of technical manpower and advanced technology, higher initial investments and maintenance costs, blanket approach for structure design and construction in terai and hills may not be appropriate (Atreya et al., 2020).

Similarly, ADS has explicitly focused on launching agricultural market information and ICT products for market intelligence, it has also acknowledged the promotion of Information Communication Technology (ICT) in agricultural extension. Likewise, the Fifteenth Plan, 2019-2024 has highlighted the inclusion of integrated and advanced ICTs in the expansion of agricultural technologies. The plan further emphasises promoting ICTs in agricultural extension services to provide information about crop forecasting, and weather information.

Kritikos (2017) traces the significant impact of agricultural policies on whether and how PF benefits the agricultural sector. The study further reveals that policymakers have recently shown an increased interest in PF because of its potential to address current issues faced by the agricultural sector. However, in the context of Nepal, we can find limited acknowledgement of PF in the policy document. Perhaps it would be safe to say that Nepal's policies should also reflect more of the involvement of PF in the agriculture sector. Implementing precision agriculture in Nepal has the potential to enhance agricultural productivity, optimise resource utilisation, and improve farmers' livelihoods. For its widespread adoption and successful implementation, a multiple-stakeholder approach, technological infrastructure, capacity development, research based on different geographical regions, and a supportive policy are necessary.

3.1.4 Supplementary Production System and Protected Agriculture Technologies

The year-round availability of water is frequently constrained in Nepal, leading to significant reliance on rainfall for the majority of crops like rice and wheat. This situation could potentially result in conflict over water resources (International Center for Tropical Agriculture et al., 2017). Given this situation, implementing supplementary technology like rainwater harvest for irrigation appears to be the most suitable approach. This paper defines supplementary production system technology as the practice of rainwater harvesting to effectively harness and manage water resources to sustain farming operations in a sustainable and resilient manner to mitigate water scarcity or drought. Our review found that only a few agricultural policies demonstrate an understanding of the importance of rainwater harvesting as

a supplement to conventional irrigation methods. The Irrigation Policy (2004) has acknowledged about development of year-round irrigation water reservoirs, rainwater harvests, and groundwater resources. Likewise, the National Agricultural Policy (2004) highlights the provision of special facilities to the target groups to build and install infrastructures of small irrigation as pedal pumps, rower pumps, sprinklers, drips, and water harvesting ponds. Also, the Agriculture Development Strategy (2015-2035) has mentioned the development of gravity piped, water harvesting, and small-scale pumped systems based on drip or sprinkler irrigation. Whereas, Climate Change Policy (2019) has an explicit provision that aims to construct rainwater harvesting ponds for groundwater recharge and their multiple uses. Technologies for storage, multiple uses, and efficient use of water will be developed and promoted in risk-prone areas and settlements considering the effects of climate change on the availability of, and access to, water. The policy also promises to protect water sources besides the development and expansion of rainwater harvesting and storage. It further emphasizes on development of water-efficient technologies to increase access and easy availability of drinking water.

Furthermore, similar to supplementary production system technology, protected agriculture technology also entails very few spaces on policy provisions. In this paper, the term 'protected agriculture technology' is used to describe the practice of establishing nurseries for plants under controlled environmental conditions (e.g. polyhouse, greenhouse). Biotechnology Policy (2006) has recognition about protected agriculture technology through private entrepreneurs, to set up laboratories, greenhouses, and nurseries with a view to producing quality and disease-free plants through biotechnology. Likewise, the Floriculture Promotion Policy, of 2013 has highlighted the establishment of flower nurseries to expand flower cultivation in different parts of Nepal.

While both supplementary production systems and protected agriculture technology offer numerous benefits, their widespread adoption in agricultural policies seems to be very limited. As a supplementary production system technology, it not only acts as an additional water conservation /management source for a consistent water supply for crops throughout the year, but it also minimizes reliance on freshwater management. Protected agriculture technology can optimise various environmental factors like extreme weather events, pests, and diseases, and improve the overall yield and quality of the crop in addition to minimising risks of farming. Hence by including such innovative approaches in policies, the government can play a crucial role in facilitating their implementation.

3.1.5 Biotechnology and Tissue Culture in Management Technologies

The significance of biotechnology and tissue culture in agriculture is paramount. These innovative approaches have opened up new possibilities for productivity improvement, disease resistance, and sustainable farming practices. The Biotechnology Policy (2006) emphasises the application of biotechnology in various areas such as bio-pesticides, bio-fertilizers, and other biotech aspects. Whereas, the NARC Vision (2011-2030) includes enhancing the screening process for quality protein maize (QPM) genotypes to improve their resistance against diseases, insects, and abiotic stresses. Marker Assisted Selection (MAS) is used in crop improvement to increase resistance to both biotic and abiotic stresses. Molecular markers are employed to enhance the characteristics of maize varieties, particularly in terms of hybrid vigour. Effective Microorganisms (EM) Technology and EM compositing are utilised to improve soil quality and overall health. Similarly, the National Science, Technology and Innovation Policy (2019) emphasizes providing support for the development and utilization of biotechnology, nanotechnology, and nuclear technology to drive agricultural sector development.

The National Seed Policy (1999) highlights the importance of conducting studies and research on biotechnology or genetic engineering specifically for genetically modified organisms (GMOs), transgenic plants, and tissue culture. The Biotechnology Policy (2006) emphasizes the use of technologies related to genetic engineering, cell culture, microbiology, biochemistry, molecular biology, and tissue culture. It encourages research on utilizing biotechnology in tissue culture for various sectors including forestry, agriculture, food grains, herbs, mushroom production, and processing systems, as well as animal and human health systems. The NARC Vision (2011-2030) promises the development of technologies using tissue and embryo culture to enhance crop productivity

3.1.6 Integration of Mechanization in Agricultural Policies

Seven of the fifty-five agricultural policies have indicated a moderate acknowledgement of mechanisation for the promotion of agricultural production. Agriculture Development Strategy (2015-2035) is the most coherent report to recognize the importance of farm mechanization, where the policy has not only promised to provide a range of mechanization options but has also assured the availability of equipment leasing services to farmers. This policy has also pledged to increase the accessibility of mechanization through awareness creation, demand stimulation, concessionary financing arrangements, capacity building, revision of regulation, tax support, pilot vouchers, and establishment of agricultural mechanisation centres in three regions of Nepal. The Fifteenth Plan (2019-2024)

also addresses the importance of mechanisation through the statement of improving and expanding agricultural mechanization through collaboration with the private sector and cooperatives based on the feasibility and need of agroecological zones.

Policies like the Agribusiness Policy (2006), National Employment Policy (2014), and National Agro-Forestry Policy (2019) have mentioned provisions of mechanisation service through modern technology, tools, and equipment. Similarly, NARC Vision has also focused on strengthening farm mechanisation operations, particularly in a rice-wheat system. The Agriculture Mechanization Policy (2014) is explicitly formulated to promote mechanisation services in Nepal. As mentioned by Shrestha (2022) almost all the policy and annual budget programs were silent on agricultural mechanisation before the declaration of the Agricultural Mechanisation Promotion Policy (2014). The finding highlights that sustainable agricultural mechanisation can be achieved only through the systematic transfer of technology to targeted farming communities and the development of human resources at all levels to address mechanisation functions, regulation, and standardisation (Shrestha 2022). The National Agriculture Engineering Research Centre (NAERC) has tested and developed dozens of agri. machinery-related production and management technologies. However, several issues have been reported due to the absence of legal documents (Timsina et al., 2022). But, the guidelines (legal document) to support agri. mechanization policy is yet to be approved.

3.1.7 The Agricultural Input-Production-Policy Nexus

Crop productivity increases with the use of improved inputs where the incentives to increase their use and adaptation are influenced by the policy (Mbithi and Huylenbroeck 2000). As previously mentioned, approximately 22 agricultural policies have emphasized improving production, including some provisions related to the management and supply of agricultural inputs like seed, fertilizer, pesticides, and farm machinery to enhance productivity. National Seed Policy (1999) emphasizes the supply of improved quality seeds for increased productivity, while the National Fertilizer Policy (2002) and Agriculture Mechanization Policy (2014) emphasize the efficient supply of fertilizer and farm machinery respectively. The Land Use Policy (2015) has provisions for the protection of arable lands and demarcation of agricultural land and the Irrigation Policy (2004) ensures year-round irrigation to the country. However, pesticides are a controversial aspect of growing food, which can contaminate soil, soil organisms, water, and food chains. Therefore, sustainable production should integrate consideration for soil health, water, food, and whole ecosystems while using inputs like pesticides, as agricultural inputs have a role in determining the soil quality on smallholder farms (Li et al., 2022). Some

recent policies, like the Agriculture Development Strategy (2015-2035), have also emphasised the adoption of an Integrated Pest Management (IPM) approach to reduce the loss of beneficial organisms and chemical contamination in soils, water, and food products. Agrobiodiversity Policy (2006), its revised version published in 2014, also supports ecological and organic production systems for the conservation and promotion of agrobiodiversity in soil, water, and ecosystems. Hence, it would be appropriate to formulate policies assessing soil, water, and food quality at the field scale and in the market and evaluate the contributions of agricultural inputs in sustainable production systems and food chains.

As per the study, the Agriculture Development Strategy (2015-2035) has addressed a pragmatic solution to fertiliser supply with soil testing and improvement services that aim to boost productivity. Similarly, the National Agricultural Policy (2004) has emphasised promoting the sale and distribution of manure, insecticides, and pesticides. Whereas policies like; the National Tea Policy (2000) and Floriculture Promotion Policy (2013) have precisely acknowledged importing chemical fertilisers, organic fertilisers, insecticides, herbicides, and pesticides from another country. Also, the National Fertilizer Policy (2002) has encouraged the use of chemical fertiliser in a balanced manner concerning required nutrients based on the soil test. On the other hand, the National Tea and Coffee Development Board Act (1999) has promised to arrange the supply of chemical fertilisers and pesticides for the farmers involved in tea and coffee farming on a small scale. Similarly, the Right to Food and Food Sovereignty Act (2018) has mentioned expanding the sustainable use of and access to environmentally friendly fertilisers, and pesticides in food production.

The Land Use Policy (2015) and National Science, Technology and Innovation Policy (2019) have mentioned the protection and management of soil, while the NARC Vision (2011-2030) has taken a step further to promote soil through- green manure/cover crops/mulching to improve or restore fertility and soil texture. It has also promised to identify and advance biological nitrogen-fixing (BNF) species to maintain soil fertility in agroforestry systems and develop conservation tillage practices to maintain soil health. However, the concern about soil improvement is still narrow among agricultural policies.

Thus, the above analysis highlights that even though increasing productivity remained one of the priorities in most of the policies, the provision of inputs like fertiliser and pesticides (which play a significant role in increasing productivity) is limited. Also, the reference to maintaining soil health in agriculture has an utmost gap across policies. In 2023, NARC has recommended balanced fertiliser doses

[Nitrogen (N), Phosphorous (P), Potassium (K), Zinc (Zn), Boron (B), and Compost] of major crops like rice, maize, and wheat to increase crop productivity and maintain soil fertility (Nepal Agricultural Research Council [NARC], 2023).

3.2 Infrastructure and Institutional Framework

To successfully promote demand-driven technology and services the Agriculture Development Strategy (ADS), (2015-2035) strives to change the structure, procedure, application, and coordination of research and extension, as well as other associated programs and institutions and also acknowledges to establish National Agriculture Research Fund (NARF), integrated with NARC: (NARF will fund action research projects to be conducted by public, private, and nongovernmental organisations to meet the demand of farmers and Agro-enterprises) to initiate in finalising the NARC Vision (2011–2030), ADS has envisioned establishment of several flagship programs like Food and Nutrition Security Plan (FANUSEP), Value Chain Development Program (VADEP), Prime Minister Modernization Project (PMAMP) to support modernisation of agriculture in Nepal (Babu & Sah, 2019). It has also commenced with the establishment of agriculture mechanisation centres in different regions of Nepal. However, the concept of functioning NARF has not been institutionalised or started yet.

On this basis, The Fifteenth Plan (2019-2024) also anticipates a substantial increase in agricultural production and productivity by introducing agricultural policies, laws, and plans in coordination and collaboration with federal, provincial, and local levels and other stakeholders. It also suggests to implement The Right to Food and Food Sovereignty Act. The Right to Food and Food Sovereignty Act (2018) has acknowledged the involvement of the Federal Provincial and Local Governments in the research and development of scientific technology for the sustainable development of agriculture.

However, government bodies (NARC, DOA, DOLS) operating under MOALD, with their national, regional, and local level networks lack the capacity and resources to meet the diversified technology and service. Despite the support of the government for encouraging the private sector to participate in research and development in Nepal, not much has been accomplished consequently leading to ineffective coordination and connections to strengthen public-private partnerships (Babu & Sah, 2019). Additionally, agriculture and forestry universities have been mandated to generate management-related technologies in Nepal.

3.3 Investment and Budget

In Nepal, about 300 million Nepalese Rupees has been directly allocated for agricultural research: to develop 15 new technologies for crops, livestock, and fisheries by the fiscal year 2022/23 (Sapkota, 2021). As NARC is a major institution in developing production system technologies, it has developed 133 projects related to the production management components which is about 34% of the total approved projects in NARC in 2022/23. This component has a sharing of 36% of the total operational budget of NARC, where operational budget comes to around 24% of the total budget in 2022/23 (NARC, 2023a) . If it is looked at the sharing of this component on the total budget, it comes to around 8.5%, including the source based seed production, which has a major share (5% of the total budget). So, the real investment on this component is very low which comes around 3.5% of the total budget (Figure 2). It is found that NARC has given priority to developing production management technologies considering pesticide and soil health, climate change, and nutrition. Conservation, biotechnology, and mechanisation are the current demands in production. However, the investment and the priority needs are not much aligned to meet the recent challenges. Timsina et al. (2023) reported that the major share of the total budget of NARC goes to breeding which comes to around 14% of the total budget that is still underfunded as envisioned in National Seed Vision (NSV) 2013-2030.

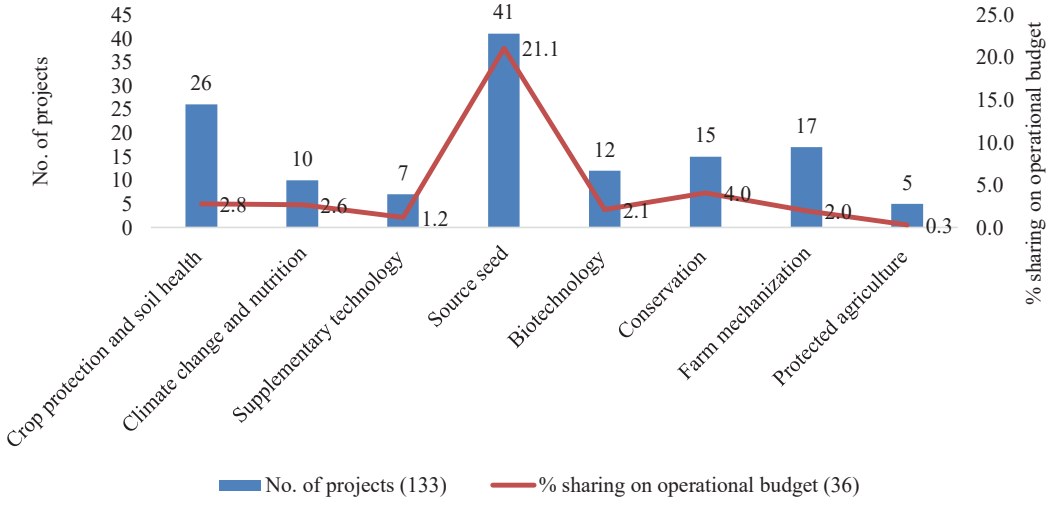

Figure 2: Number of projects and operational budget sharing regarding production management of NARC in FY 2022/23

Policies and strategies formulated to address agricultural progress in the nation through the formulation of specific budgets and incentives targeted toward the

growth of agricultural production are vital to checking the entire country's economy. Agriculture Development Strategy (ADS) closely collaborates with the Ministry of Industry (MoI) and Nepal Investment Board to enhance the investment climate, facilitate and regulate Foreign Direct Investment (FDI), and attract foreign investment in the agricultural sector. Private investment has a crucial role in the adoption of new technology. However, the investment in the agricultural sector is not sufficient and does not promote private investment, which results in low productivity, less commercialisation, and a decreasing contribution to GDP (Lamichhane, 2022). Further, FDI is important for agricultural infrastructure development, technology generation, capacity building of human resources, and increased efficiency but it must not harm small and marginalised farmers (Pant et al., 2022). Therefore, FDI in agriculture is requisite for the processing industry, technology generation, and marketing but government needs to be aware to protect the rights of the smallholder farmers. It has further ensured the integration of long-term plans with annual work and budget through amending the National Planning Commission Formation and Operation Order (2010), and promoting the formulation of the Rights to Food and Food Sovereignty legislation. Even though much of an investment has been planned there is limited private sector investment in agriculture; partially because of an unstable political scenario and the other half because of risk and lack of a conducive environment for investment. As the nation moves towards a federal political system, agricultural productivity can be accelerated through ownership of public investments by provincial and local governments (Thapa et al., 2019; Poudel & Wagle, 2019). It has been seen from the review, that most of the policy documents lack participation in decision-making related to technology development to enhance crop production. Dhungel & Shrestha (2019) describe the reason for poor technologies as the result of low investment in agriculture which has continuously affected agriculture research, degraded human resources, and lowered access of farmers to extension creating limited technologies to meet the needs of diverse clients. In contrast, through demonstration from several studies, it was found that financial and social remittances earned by migrants from rural areas have been a huge asset in financing technologcal development in Nepal (Thapa et al., 2019).

3.4 Human Resources Development

Nepal exhibits a peculiar pattern that defies the contribution of agriculture production through the development of improved technologies and trained human resources. Among the few policies that acknowledge the improvement of manpower, the National Seed Policy, (1999) has addressed preparing human resources and physical infrastructure for the development of sophisticated technologies. Floriculture

Promotion Policy, (2013) promises to provide skilled manpower and physical infrastructure to government agencies involved in technology development and technology dissemination in the flower sector. Whereas the Bee-Keeping Promotion Policy (2016) has remotely acknowledged the development of skilled manpower in NARC.

NARC is a major technology-generating organisation working in Nepal which has less than 50% scientific manpower working for research. In NARC, 239 scientific staff have been working currently and about 75% of these scientific staff have been working to develop production management technologies. The main priority of the projects (based on the involvement of the staff) in this component goes to production and productivity enhancement, and source seed production. However, other themes such as pesticide and soil health, climate change and nutritional areas, biotechnology, farm mechanisation, conversation, and protected agriculture have been gaining importance (Figure 3). The availability and allocation of scientific manpower is also not qualified enough to meet the demand.

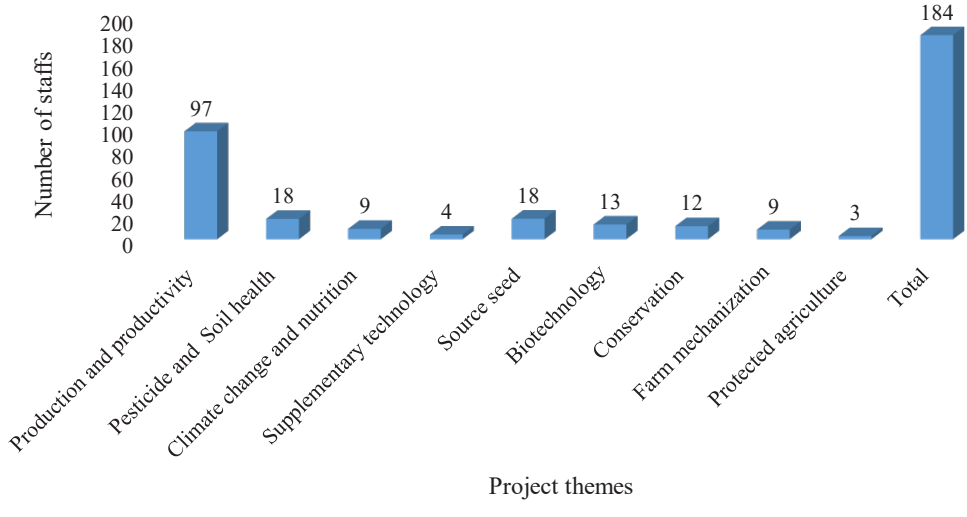

Figure 3: Number of scientific manpower engaged in different production management projects in NARC in 2022/23

4. Conclusions

The study examines how agricultural policies and acts contribute to promoting agriculture in Nepal, particularly concerning production and management technologies. It highlights existing provisions made for the promotion of agricultural

technologies, innovations, and management. It was found that most of the policies have recognised the need to enhance agricultural productivity, but lack comprehensive strategies for technology adoption and implementation. Policy revisions should integrate agricultural technologies to improve farmers' income through quality food production. Policy provisions related to the technologies for production, maintenance, and delivery of sources seeds/stocks, particularly for native and indigenous crops, livestock, and fisheries, are weak, which are critical for increasing production and productivity.

While NARC played a crucial role in developing agricultural technologies, farmers still struggle with limited resources and information access. Likewise, climate change adaptation is recognised, but greater emphasis on mitigation is needed. Also, precision agriculture has potential, but adoption remains limited. The importance of rainwater harvesting and protected agriculture technologies is understated in policies. While biotechnology and tissue culture need better integration into agricultural policies. Mechanisation is moderately addressed, requiring improved technology transfer and human resource development. The study found that the current resource allocations for innovative production systems and management technologies are inadequate to address emerging needs for increasing agricultural productivity, ensuring food security, and adapting to a changing climate. Particularly, it is the right time to focus on climate-smart technologies which are the major challenges in the present context. Recognizing the importance of human resources, institutions, and financial contributions is essential for improving production and management system technologies. Encouraging collaboration between government agencies, private sectors, and research institutions is vital for effective policy implementation. It is also important to link developed technologies with local government for their effective dissemination and utilization. An inclusive approach and enhancement can lead to resilience, productivity, and sustainable growth in Nepal's agricultural sector.

5. Policy Recommendation

The following policy recommendations are outlined based on the findings of the study.

- Policy provisions on the conservation and utilization of indigenous and local genetic resources and maintenance and multiplication of source seeds and breeds are very important while developing and scaling production technologies for their sustainable use.

- Increasing investment in agricultural research and development aligning with national agricultural strategies is vital to address emerging challenges such as food safety, climate change, soil degradation, nutrition security, biotechnology, pest management, etc.
- Develop inclusive agricultural mechanisation directives that support the testing, validation, and adoption of modern farming machinery and technologies considering technology transfer and capacity building of farmers.
- Integrate input supply policies with production strategies of national policies to ensure the efficient use and supply of seeds, fertilisers, pesticides, and machinery including water use efficiency.
- Prioritize research and development strategies in organic and bio-fertiliser-based alternatives to minimise the reliance only on chemical inputs that deteriorate soil health and pollute the environment.

6. Suggested Course of Action

We have suggested the following course of action to implement the recommendations. The suggestions are based on the authors' discussion and consultation with the relevant stakeholders and policymakers. The recommendation and the suggested course of action were validated in the progress review workshop organised by the Nepal Agricultural Research Council (NARC).

S.No	Recommendation	Responsible Agencies	Suggested Action
1.	Conservation and utilisation of locally adapted indigenous and local genetic resources	NARC and other research organisations	Utilisation of local genetic resources in breeding programs to develop and promote the supply of improved locally adapted varieties and breeds by maintaining and multiplying their source seeds and breeds
		National Agriculture Genetic Resources Centre (Genebank)	Collection and maintenance of the genetic resources, and providing pre-breeding materials to related commodity programs
		Federal Ministry of Agriculture and Livestock Development (MOALD)	Facilitation for registration, maintenance, and utilisation of the locally adapted genetic resources
		Farmers Organisation	Operation of community seed banks and resource centres
		Provincial and Local Governments	Facilitation for registration and utilisation of locally adapted genetic resources

S.No	Recommendation	Responsible Agencies	Suggested Action
			Establishment of seed banks and resource centres
		Universities	Incorporate the importance of indigenous and local resources in the course curriculum. Also, utilise the local genetic resources in breeding programs to meet domestic demand
2.	Increase investment in agricultural research and development	National Planning Commission (NPC) and Federal MoALD	Collaborate with relevant stakeholders to increase funding for agricultural research and development Research prioritisation and budget allocation based on national demand
		Federal MOALD	Attract donors to increase funding and prioritise agricultural research
		Ministry of Finance (MOF)	Allocate sufficient funding for agricultural research and development
3.	Inclusive agricultural mechanisation directives	Federal MOALD	Formulate a directive that supports the inclusive testing and adoption of modern farming machinery and technologies Facilitate training and capacity-building programmes and assure equitable access to mechanisation services across different farm sizes, social groups, and regions
		Private sectors	Collaborate with NARC for testing and validation
		Federal Government	Approval of agricultural mechanisation directive
4.	Integrate input supply policies with production strategies	Ministry of Industry, Commerce and Supplies (MOICS) & Federal MOALD	Organise a program to review and identify gaps regarding input supply policies and production strategies jointly
		Policy Research Institute (PRI)/ National Planning Commission	Review different input supply policies and production strategies to integrate them, and recommend the formulation of integrated input supply and production strategy with a detailed action plan

S.No	Recommendation	Responsible Agencies	Suggested Action
5.	Research and development strategies for inorganic and bio-fertiliser	NARC and other research organisations	Invest in research for alternative and balanced use of chemical fertiliser focusing on different options of bio-fertiliser Increase infrastructure and human resources on organic agriculture
		Universities	Foster collaboration between research institutions and universities for joint research and offer specialised agriculutural courses
		Industries	Provide funding for research and development Increase collaboration with other public organizations like NARC, Universities, etc. Integrate research output into production
		Ministry of Forest and Environment	A collaborative program with MOALD
		Federal and Provincial MOALD	Pilot program for promoting bio-fertiliser (based on research findings)

Authors Contribution Statement

Krishna Prasad Timsina: Conceiving ideas; formulation of overarching research goals and aims; design of methodology; application of study framework; conducting the research and investigation process, drafting and finalization of manuscript.

Devendra Gauchan: Conceiving ideas; formulation of overarching research goals and aims; design of methodology; application of study framework; conducting the research and investigation process, drafting and finalization of manuscript.

Shreeya Tripathi: Design of methodology; application of study framework; conducting the research and investigation process, finalization of manuscript.

Sabin Basi: Design of methodology; application of study framework; conducting the research and investigation process, drafting and finalization of manuscript.

Surya Prasad Adhikari: formulation of overarching research goals and aims; design of methodology; application of study framework; conducting the research and investigation process, finalization of manuscript.

Conflict of Interest Statement

The author's declared no conflict of interest.

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Annex

Annex 1: Reviewed Agricultural Policies, Strategies, Visions and Plan

SN	Policies	Date	SN	Policies	Date
1	Foreign Investment and One-Window Policy	1992	26	Floriculture Promotion Policy	2013
2	National Seed Policy	1999	27	Seed Vision	2013-2025

SN	Policies	Date	SN	Policies	Date
3	National Tea Policy	2000	28	Agricultural Mechanization Policy	2014
4	National Fertilizer Policy	2002	29	National Employment Policy	2014
5	Foreign Aid Policy	2002	30	Foreign Investment Policy	2014
6	National Coffee Policy	2003	31	Agriculture Development Strategy	2015-2035
7	Rural Water Supply and Sanitation National Strategy	2004	32	Constitution of Nepal	2015
8	Rural Water Supply and Sanitation National Policy	2004	33	Land Use Policy	2015
9	Irrigation Policy	2004	34	National Youth Policy	2015
10	National Nutrition Policy and Strategy	2004	35	Commerce Policy	2015
11	National Agricultural Policy	2004	36	Public Private Partnership Policy	2015
12	Herbs and non-timber forest products development policy	2004	37	Rural Energy Policy	2016
13	Labor and Employment Policy	2005	38	Bee-Keeping Promotion Policy	2016
14	Agro-Biodiversity Policy	2006	39	National Intellectual Property Policy	2017
15	Biotechnology Policy	2006	40	National Food Security Policy	2018
16	Agribusiness Promotion Policy	2006	41	National Food Safety Policy	2018
17	Dairy Development Policy	2007	42	National Food Hygiene Policy	2018
18	Tourism Policy	2008	43	National Land Policy	2019
19	International Development Assistance Operational Policy	2011	44	International Development Cooperation Policy	2019
20	Industrial Policy	2011	45	National Environment Policy	2019
21	Poultry Policy	2011	46	Poverty Alleviation Policy	2019
22	NARC Vision (yet to be approved)	2011-2030	47	National Agro-Forestry Policy	2019
23	Rangeland Policy	2012	48	The Fifteenth Plan	2019-2024
24	Supply Policy	2012	49	National Science, Technology and Innovation Policy	2019
25	National Cooperative Policy	2013	50	Climate Change Policy	2019

SN	Policies	Date	SN	Policies	Date
51	Monetary Policy	2021	53	National Animal Health Policy	2021
52	National Livestock Breeding Policy	2021	54	National Fisheries Development Policy	2022

Annex 2: Reviewed Agricultural Acts

SN	Act	Date	SN	Act	Date
1	Essential Goods Protection Act	1955	17	Animal Health and Livestock Services Act	1999
2	Export-Import Control Act	1957	18	Companies Act	2006
3	Land Act	1964	19	Poverty Alleviation Fund Act	2006
4	Food Act	1967	20	Plant Protection Act	2007
5	Pasture Land Nationalization Act	1974	21	Tobacco Products (Control and Regulatory) Act	2011
6	Black-marketing and Some Other Social Offenses and Punishment Act	1975	22	Deposit and Credit Fund Act	2016
7	Feed Act	1976	23	Special Economic Zone Act	2016
8	The Guthi Corporation Act	1980	24	Local Government Operation Act	2017
9	Nepal Standards (Certification Mark) Act	1988	25	Cooperatives Act	2017
10	The Seeds Act	1992	26	The Labor Act	2017
11	Nepal Agricultural Research Council Act	1992	27	National Inclusion Commission Act	2017
12	National Dairy Development Board Act	1992	28	National Women Commission Act	2017
13	National Cooperative Development Board Act	1993	29	The Right to Food and Food Sovereignty Act	2018
14	National Tea and Coffee Development Board Act	1999	30	The Consumer Protection Act	2018
15	Animal Slaughterhouse and Meat Inspection Act	1999	31	The Foreign Investment and Technology Transfer Act	2019
16	Nepal Veterinary Council Act	1999	32	Public Private Partnership and Investment Act	2019

Annex 3: Crop Management, Production System Technologies, and Innovations-related Indicators used in the analysis

Policy Provisions /Indicators
1. Productivity & production improvement
2. Climate resilience /adaptation, risk reduction and mitigation
3. Supplementary technology development and management
4. Production of sources seeds, breeds and other planting materials
5. Application of biotechnology and nano-technology for agricultural technology development and management
6. Conservation and utilization of indigenous/local resources/materials through both participatory and conventional breeding
7. Farm Mechanization and Modernization
8. Protected agriculture technologies
9. Precision agriculture technologies including information and communication technology (ICT)
10. Tissue culture for agricultural technology development and management
11. Public-private partnership for improvement of agricultural technology
12. Pesticides and soil health
13. Quality improvement technologies (nutrition and food safety)

Annex 4: Policy Provisions regarding Crop Management, Production System Technologies, and Innovations in Different Agricultural Policy Documents

S.N	Agricultural Policies	Crop Management, Production System Technologies, and Innovation-related Provisions
1.	National Seed Policy 1999	Public and private sectors will be encouraged to work in collaboration with national or international seed entrepreneurs for the development of seeds and increase production. (1) Study and research will be carried out on Biotechnology or Genetic engineering for GMOs, transgenic plants, and tissue culture. (10) Emphasis will be given to the use of tissue culture for the production of disease-free seeds and seedlings. (10)
2.	National Tea Policy 2000	The fertilizers, pesticides, weedicide, and Agricultural equipment required for the Tea business shall be allowed to be imported from other Countries. (12)
3.	National Fertilizer Policy 2002	Farmers shall be encouraged to use chemical fertilizers in a balanced manner concerning required nutrients based on the soil test. (12)

S.N	Agricultural Policies	Crop Management, Production System Technologies, and Innovation-related Provisions
4.	National Coffee Policy 2003	Maintain and improve the quality of coffee, for which appropriate improvement works shall be carried out. (13) Modern and improved technologies shall be developed and disseminated with coordination from the Government and private sector through the establishment of the research center, service center, and improvement of the present Coffee development centers. (13, 11) Organic production of Coffee shall be promoted, by organizing different promotional Programs & campaigns highlighting the importance of organic farming. (12)
5.	Irrigation Policy 2004	The provisions of quantitative measurement in the irrigation facility shall be introduced. The effectiveness of monitoring the irrigation will be held based on water quantity provided for each crop, irrigated area, and increase in production. (1) For expanding year-round irrigation water reservoirs, rainwater harvests, and groundwater resources shall be developed, conserved, promoted, and utilized. (3) Geographical and managerial information systems (GMIS) shall be updated at every level of implementation of the irrigation program and the process of strengthening the institutional aspect of the monitoring and evaluation system shall also be perpetuated in this regard. (9)
6.	National Agricultural Policy 2004	Agricultural production and productivity shall be increased by utilizing the local potentialities, comparative advantages, and special opportunities, ensuring the development, extension, and utilization of appropriate agricultural technologies. (1) Comparatively large projects that cover more than one district promote potential agricultural production, and enterprises shall be operated and supported as central projects along with the participation of the local bodies. (1) Special facilities shall be provided to the target groups to build and install such infrastructures of small irrigation as pedal pumps, rower pumps, sprinklers, drips, and water harvesting ponds. (3) A survey/surveillance system shall be established and activated to assess the impact of excessive rains, droughts, diseases, insects, and other natural calamities and mobilize agricultural reliefs. (9) Organic farming shall be encouraged. Necessary support shall be provided for the certification of the standard of exportable agricultural products produced in production areas based on organic farming. (12) The production, use, and promotion of organic fertilizers shall be encouraged. (12)

S.N	Agricultural Policies	Crop Management, Production System Technologies, and Innovation-related Provisions
		The sale and distribution of manure, insecticides, and pesticides shall be regulated, and quality shall be maintained in their supply. (12)
7.	Agro-Biodiversity Policy 2006	Public participation in the interest of farmers based on agricultural biodiversity shall be encouraged to prioritize employment and increase production. (1)
8.	Biotechnology Policy 2006	Emphasize the development of biotechnology that may assist in environmental protection and the management of natural resources. (5) Emphasis on the use of biotechnology for Bio-pesticides, Bio-fertilizer, and other Biotech Aspects shall be given. (5) Private entrepreneurs to set up laboratories, greenhouses, and nurseries with a view to producing quality and disease-free plants through biotechnology shall be encouraged. (8) Technologies relating to genetic engineering or cell culture, microbiology, biochemistry, molecular biology, and tissue culture shall be used. (10) Research to use biotechnology in tissue culture, forest, agriculture and food grains, herbs, mushroom production, and processing systems including animal and human health systems shall be encouraged. (10)
9.	Agribusiness Promotion Policy 2006	Provision of Services like; agricultural output material, irrigation, insurance, agriculture mechanization, and market set-up in agricultural production regions through cooperation of governmental, non-governmental, cooperative, and private sector. (7, 11) Agribusiness shall be promoted through products produced by organic farming. (12)
10.	Tourism Policy 2008	A program shall be introduced to increase agricultural production in a tourist area and tourist routes in coordination with the Ministry of Agriculture. (1)
11.	Poultry Policy 2011	Based on a suitable environment, organic production shall be encouraged. (12)
12.	NARC Vision 2011-2030	Productivity of oilseeds, winter and summer legumes with emphasis on tolerance to drought and other stresses will be enhanced. (1) Generation and promotion of off-season vegetable and floriculture-related technologies. (13) Identification, development, and promotion of climate-friendly agricultural technologies to adapt to climate change and contribute to sustainable agriculture development while maintaining agroecosystems and agro-bio-diversity. (13)

S.N	Agricultural Policies	Crop Management, Production System Technologies, and Innovation-related Provisions
		Development of Climate-friendly agricultural technologies to adapt to climate change. (13)
		Development of technologies in early and full season OPV maize genotypes to enhance maize productivity in hills and terai. (13)
		Strengthen the screening of QPM genotypes against disease, insect, and abiotic stresses. (5)
		Development of hybrid maize technology to enhance maize productivity in the subtropical region of Nepal. (13)
		Develop proper nutrient and water management technologies for boro, spring, and main season aerobic and transplanted rice. (13)
		Develop proper moisture conservation technologies both for upland and lowland rain-fed cropping systems. (13)
		Develop proper technology for low cost, water saving, and resistance to drought and pests. (13)
		Enhancement of productivity of oilseed crops in Nepal. (1)
		Increasing productivity and sustainability of potato crops through the development /dissemination of improved cultivation practices suitable for different production environments. (1)
		Develop appropriate technologies for soil, water, and pest management practices. (13)
		Develop a cost-effective crop management package of practices based on organic cultivation principles. (13)
		Development of technologies through tissue and embryo culture to improve crop productivity. (1,10)
		Develop a methodology for the different crop areas and yield estimation before harvest to improve preparedness for any extreme situations. (2)
		Marker Assisted Selection (MAS) in crop improvement for resistance to biotic and abiotic stresses. (5)
		Application of molecular markers toward the improvement of maize varieties for hybrid vigor. (5)
		Effective Microorganisms (EM) Technology and EM Composting to improve soil quality and health. (5)
		Strengthen farm mechanization operations in a rice-wheat system including minimum tillage. (7)
		Green Manure/Cover Crops/Mulching to improve or restore fertility and soil texture. (12)

S.N	Agricultural Policies	Crop Management, Production System Technologies, and Innovation-related Provisions
		Develop a package of practices for organic farming. (12) Identification and promotion of biological nitrogen-fixing (BNF) species to maintain soil fertility in agroforestry systems. (12) Develop conservation tillage practices to maintain soil health and improve water retention. (12)
13.	Rangeland Policy 2012	The production of organic products will be promoted by linking the value chain of cost-effective products. (12)
14.	National Cooperative Policy 2013	Special facilities will be provided to farmers participating in cooperatives to encourage the use of advanced technology and organic farming to increase the productivity of the agricultural sector. (1)
15.	Floriculture Promotion Policy 2013	The establishment of flower nurseries will be encouraged to expand flower cultivation in different parts of Nepal. (8) Arrangements will be made to import chemical fertilizers, organic fertilizers, insecticides, herbicides, and agricultural materials from other countries on the recommendation of the flower industry and flower nurseries. (8, 12)
16.	Agricultural Mechanization Policy 2014	Enhancement of agricultural production through mechanized agriculture. (1,7) Establishment of a custom hiring center for farm machinery. (7) Agricultural equipment suitable for Different Geographical structures of Nepal that can be afforded by smallholder farmers will be developed, established, and researched. (7) Priority in research and design of location-specific women-friendly machinery. (7) Modification and development of a traditional form of agricultural equipment through research and innovation. (7) Encouragement of Public-Private partnerships for the introduction, production, and development of agricultural machinery. (7,11)
17.	National Employment Policy 2014	Through irrigation, agricultural materials, and modern technology (Power tillers, threshers, and common types of harvesters that transport crops from the farm to the market), the productivity of those involved in the agricultural sector will be increased and special emphasis will be given on planting high-value crops. (1,7) By improving the productivity of the export-oriented agricultural sector, competitive stability will be expanded and emphasis will be placed on the marketing of agricultural products. (1)

S.N	Agricultural Policies	Crop Management, Production System Technologies, and Innovation-related Provisions
		The increase in the productivity of agricultural products, innovation, and value addition, and the value chain will support the national economy coupled with the global market; through appropriate policy initiatives, the productivity and economic status of people, who are involved in agriculture will be improved. (1) Special encouragement will be given to the youth to get employment at the local level by providing agricultural goods such as agricultural loans, materials, and equipment (power tillers, threshers, transport vehicles from the production site to the market). (7)
18.	Foreign Investment Policy 2014	Foreign investment will be emphasized in national priority areas such as infrastructure development, productivity improvement, and competitive sustainability development. (1) Productivity will be increased by introducing capital, modern technology, and managerial skills in industries that replace imports and meet national needs. (1)
19.	Agriculture Development Strategy 2015-2035	Agricultural production and productivity shall be increased by utilizing the local potentialities, comparative advantages, and special opportunities, and ensuring the development, extension, and utilization of appropriate agricultural technologies. (1,13) A pragmatic solution shall be adopted for fertilizer supply that aims to improve productivity. (1) Implement integrated water resource management. (3) Build resilience for farmers to climate change, disasters, price volatility, and idiosyncratic shocks through the adoption of the stress-tolerant crop, the establishment of an early warning system (EWS), access to farmers' welfare Fund, food and seed reserves systems, and climate-smart agricultural practices. (2) Develop NCI; including gravity piped, water harvesting, and small-scale pumped systems based on drip or sprinkler irrigation. (3) A range of mechanization options accessible to farmers with equipment leasing service shall be made available. (7) Support mechanization with awareness creation, demand stimulation, concessionary financing arrangements, capacity building, and appropriate taxation. (7) Mango Development in the eastern region and Nursery Development. (8) Agricultural market information and ITC products shall be launched for market intelligence. (9)

S.N	Agricultural Policies	Crop Management, Production System Technologies, and Innovation-related Provisions
		The ADS will help improve the surveillance system for zoonotic diseases, improve diagnostic capacity and testing, and improve response capacity. (9)
20.	Constitution of Nepal 2015	Enhance product and productivity by carrying out land pooling, while discouraging inactive land ownership. (1) Commercialization, industrialization, diversification, and modernization of agriculture, by pursuing land-use policies to enhance agriculture products and productivity while protecting and promoting the rights and interests of the farmers. (1, 7)
21.	Land Use Policy 2015	Protection of soil by maintaining its natural core shall be encouraged. (12)
22.	National Youth Policy 2015	Opportunities for full employment for the semi-employed youth shall be created through modernization and professionalization of the agricultural sector. (7)
23.	National Intellectual Property Policy 2017	Priority will be given to the development of new technologies that utilize the maximum amount of intellectual property to increase the competitive strength, quality, and productivity of manufactured goods and services. (1,13)
24.	National Land Policy 2019	Cooperative farming shall be encouraged through commercialization and mechanization to increase production. (1)
25.	International Development Cooperation Policy 2019	Mobilization of development cooperation; to achieve high economic growth, increase production and productivity, create wider employment opportunities, and promote export-oriented production. (1) The Government of Nepal will mobilize, implement, monitor, and evaluate international development cooperation resources, with attention to their contribution to agricultural modernization, energy development, and increasing production and productivity. (1, 7)
26.	Poverty Alleviation Policy 2019	To increase agricultural production and make the country self-sufficient in food security, coordinate with the relevant agencies to ensure the access of the poor to land. (1)
27.	National Agro-Forestry Policy 2019	Necessary infrastructure like irrigation, tools, equipment, technology, and other facilities shall be made available for commercial and communal agroforestry. (7)

S.N	Agricultural Policies	Crop Management, Production System Technologies, and Innovation-related Provisions
28.	The Fifteenth Plan 2019-2024	Production shall be increased by ensuring the classification and utilization of land based on capacity, suitability, and needs according to the Land Use Policy. (1) Productivity will be increased by improving the production regulatory mechanism and the cost of doing business. (1) Increase agricultural production and productivity by introducing agricultural policies, laws, and plans in coordination and collaboration with federal, provincial, and local levels and other stakeholders. (1) Resilient technologies will be developed and expanded to mitigate the effects of climate change in coordination and collaboration with education, research, and communication agencies. Similarly, the development and utilization of bio-fortified crops and other products will be expanded. (2) Agricultural biodiversity will be preserved, promoted, and sustainably utilized by guaranteeing programs and budgets for climate adaptation and resilient technologies. (2) Studies and research will be conducted in the fields of space science and technology, atomic science and technologies, Nanotechnologies, and biological sciences and technologies. (5) Agricultural mechanization will be improved and expanded in collaboration with the private sector and cooperatives based on the feasibility and need of agroecological zones. (7) The private sector shall be motivated to promote the commercialization, modernization, and industrialization of the agricultural sector. (7) Integrated and advanced ICTs will be used in the expansion of agricultural technologies. (9) Potential products and production zones will be identified for organic farming. (12)
29.	National Science, Technology, and Innovation Policy 2019	Productivity and quality of production shall be enhanced through scientific research, technology development, and innovation thereby assisting in economic growth. (1,13) Scientific research and technology shall be developed and utilized for emergency security, climate change adaptation, and disaster risk reduction. (2) Biological, Nano and other innovative technology shall be used for soil management. (5, 12) Assistance shall be provided for the development and utilization of bio, nano, and nuclear technology, for agricultural sector development. (5)

S.N	Agricultural Policies	Crop Management, Production System Technologies, and Innovation-related Provisions
		Modern technologies shall be used for diversification and modernization of the agricultural sector. (7) The partnership shall be developed among academic institutes, research institutes, and industrial enterprises for the promotion of scientific research, technology development, and innovation. (11)
30.	Climate Change Policy 2019	Technologies that protect the crop from climate-induced disasters like drought and cold waves will be developed and expanded. (2) Rainwater harvesting ponds will be constructed for groundwater recharge and their multiple uses. (3) Technologies for storage, multiple uses, and efficient use of water will be developed and promoted in risk-prone areas and settlements considering the effects of climate change on the availability of, and access to, water. (3) Water sources will be protected besides the development and expansion of rainwater harvesting and storage and water efficient technologies will be developed to increase access to, and easy availability of, drinking water. (3) Crop diversification, protection of agricultural biodiversity, and the organic farming system will be promoted. (12)

Note: The number in parentheses indicates the policy indicators

Annex 5: Policy Provisions regarding Crop Management and Production System Technologies and Innovations in different Agricultural Acts

S.N	Acts	Crop Management, Production System Technologies, and Innovation-related Provisions
1.	National Tea and Coffee Development Board Act, 1993	Arrange, or cause to be arranged, for the supply of such loans, seeds, plants, chemical fertilizers, pesticides, equipment, fuels, and technical service, among others, as may be required for the farmers who do the tea and coffee farming on a small scale. (12)
2.	Local Government Operation Act, 2017	Nursery establishment, production, and distribution of seeds and seedlings. (8) Promotion and dissemination of organic farming and fertilizers. (12)

S.N	Acts	Crop Management, Production System Technologies, and Innovation-related Provisions
3.	The Right to Food and Food Sovereignty Act, 2018	To make sustainable development of agriculture, increase food products, or promote food and nutrition security, the Government of Nepal, Provincial Government, and Local Level shall arrange the necessary study, research, and development of scientific technology. (1) Professionalize, industrialize, modernize, and mechanize agriculture to protect agricultural occupation. (7) Expand the sustainable use of and access to improved technology, environment-friendly fertilizers, and various types of seeds, pesticides, or agricultural materials in food production. (12) Expand access of the farmers to infrastructures needed for organic farming. (12)